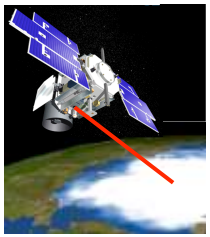


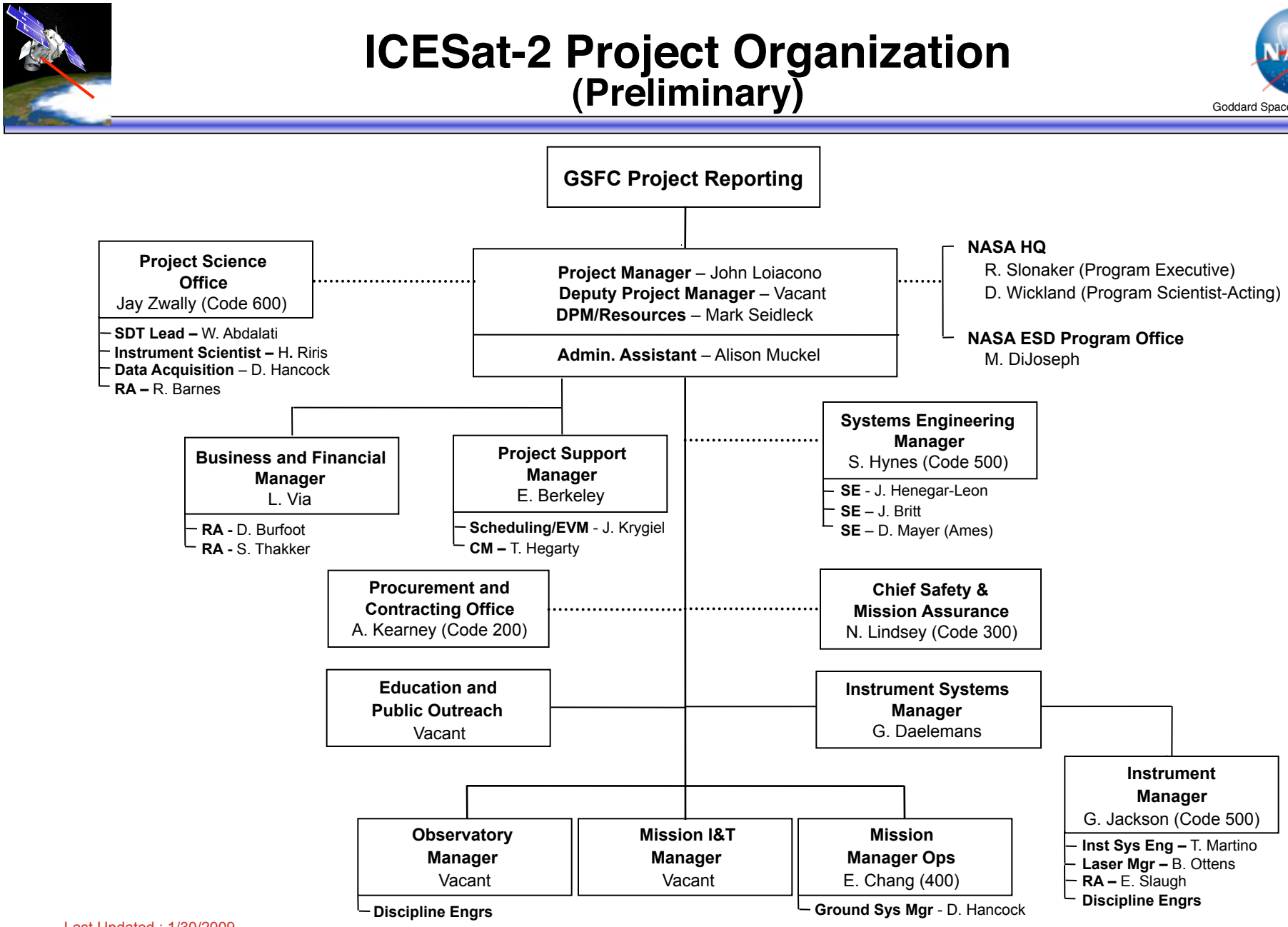
Goddard Space Flight Center

ICESat-2 Progress Report for FY08 and FY09 Plans

John Loiacono
NASA/GSFC
February 11, 2009

ICESat-2 Project Organization
(Preliminary)

Goddard Space Flight Center



Last Updated : 1/30/2009

ATLAS Instrument Pre-Phase A Team

Goddard Space Flight Center

ICESat-2 Project Office

Science Team

N/A
E/PO Mgr.

Elaine Slaugh
Resource Analyst
N/A
Contract Officer
N/A
CMO
N/A
EEE Parts
Joe Krygiel
Planner

G. Jackson
IM

Mission Assurance Specialists:
N. Lindsey
QAE
N/A
Parts Eng.
N/A
Radiation
N/A
Safety
N/A
FSW QAE
TBD
Materials AE
N. Lindsey
Reliability

H. Riris
Instrument Scientist

K. Cousler
Transmitter Cleanroom Build Lead

T. Martino
Lead Systems Engineer
R. Bartlett
Systems Engineer
M. Maldonado
Systems Engineer

J. McGarry
Algorithms

B. Ottens Team Mgr
A. Seas, Sys. Eng.
Laser Integrated Product Team

H. J. Wood
Optics

G. Yang
Detector IPT

TBD
BCE

T. Correll
LRS

TBD **Det. Boards**

J-P Swinski
Software

S. Schmidt
Mechanical Systems

E. Grob
Thermal Systems

TBD
Electrical Systems

D. Hughes
Contam.

TBD
I&T

J. Budinoff, **Mechanisms**

S. Cooper, **Structures**

J. McCabe, **IEM IPT**

ICESat-2 Science Definition Team
(Selected December 2008)

Goddard Space Flight Center

- Waleed Abdalati, Univ. of Colorado: ice sheets, SDT Leader
- Robert Bindschadler, NASA GSFC: ice sheets
- Bea Csatho, Univ. of Buffalo: ice sheets
- Helen Fricker, Scripps Institution of Oceanography: ice sheets
- Ben Smith, Univ. of Washington: ice sheets

- Ron Kwok, JPL: sea ice
- Thorsten Markus, NASA GSFC: sea ice

- Michael Lefsky, Colorado State Univ.: vegetation
- Ross Nelson, NASA/GSFC: vegetation
- Birgit Petersen, USGS: vegetation

- Alexander Marshak, NASA GSFC: atmospheric science
- Steve Palm, SSAI: atmospheric science
- Bob Schutz, Univ. of Texas: Geodesy
- Dave Harding, NASA GSFC, Solid Earth
- Mike Jasinski, NASA GSFC, Hydrology

Ice Sheets
Sea Ice
Vegetation
Other

ICESat-2 Ad-Hoc Science Team

March-November 2008

Goddard Space Flight Center

- W. Abdalati*, Univ. of CO: ice sheets
- R. Bindschadler, NASA GSFC: ice sheets
- B. Csatho, Univ. of Buffalo: ice sheets
- H. Fricker, Scripps: ice sheets
- U. Herzfeld, Univ. of CO: ice sheets
- W. Krabill, NASA GSFC/WFF: ice sheets
- C. Shuman, UMBC: ice sheets
- B. Smith, Univ. of Wash.: ice sheets
- J. Zwally, NASA GSFC: ice sheets/sea ice
- S. Farrel, NRC/NOAA: sea ice
- R. Kwok, JPL: sea ice
- T. Markus, NASA GSFC: sea ice
- M. Lefsky, Colorado State Univ.: veg
- R. Nelson, NASA/GSFC: veg
- J. Ranson, NASA GSFC: veg
- M. Simard, JPL: veg

- A. Marshak, NASA GSFC: atmos
- S. Palm, SSAI: atmos
- J. Spinhirne, NASA GSFC: atmos
- W. Wiscombe, NASA GSFC: atmos
- C. Birkett, U. of MD College Park: hydrol
- M. Jasinski, NASA GSFC: hydrology
- D. Harding, NASA GSFC: solid Earth
- C. Carabajal, Sigma Space: land/geodesy
- S. Luthcke, NASA GSFC: geodesy
- B. Schutz, Univ. of Texas: geodesy
- T. Urban, University of Texas: geodesy
- C. Webb, University of Texas: geodesy
- J. Moisan, NASA GSFC/WFF: oceans
- D. Hancock, Consultant: data analysis

*** Ad hoc SDT Lead**

ICESat-2 Mission Description

Goddard Space Flight Center

Science Objectives

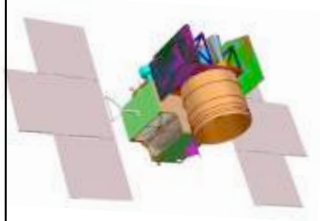
1. Determine polar ice sheet mass balance; understand controlling mechanisms; examine how ice sheets will impact global sea level and ocean circulation in a changing climate.

2. Measure sea-ice thickness to understand ice/ocean/ atmosphere exchanges of energy, mass and moisture.

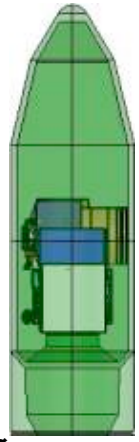
3. Vegetation cover and global biomass.

Mission Concept

1. Repeat ICESat ground-track
2. Orbit: 600 km, circ, 94 inclination, 91-day repeat
3. Pointing accuracy ± 10 arcseconds (± 30 m on ground)



Notional S/C Bus and instrument configuration



ICESat-2 in Taurus II Fairing

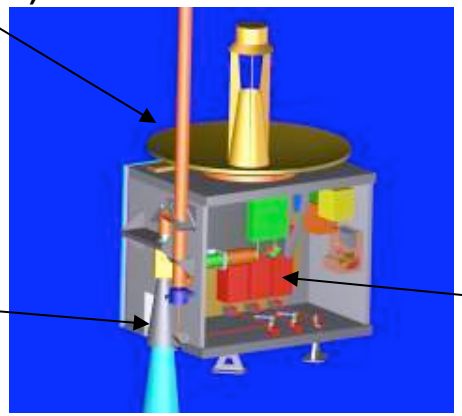
Instrument Concept

Ice Altimeter

1. One laser on at a time, 50 Hz rep rate, 50 mJ, 50-70m beam footprint with 140m spacing
2. Surface range precision of 1-2cm
3. Ice footprint location knowledge to 4.5m on ground using Laser Reference System (LRS)

Instrument Concept

1.0 - 1.5m Telescope (reduces laser energy reqm't)

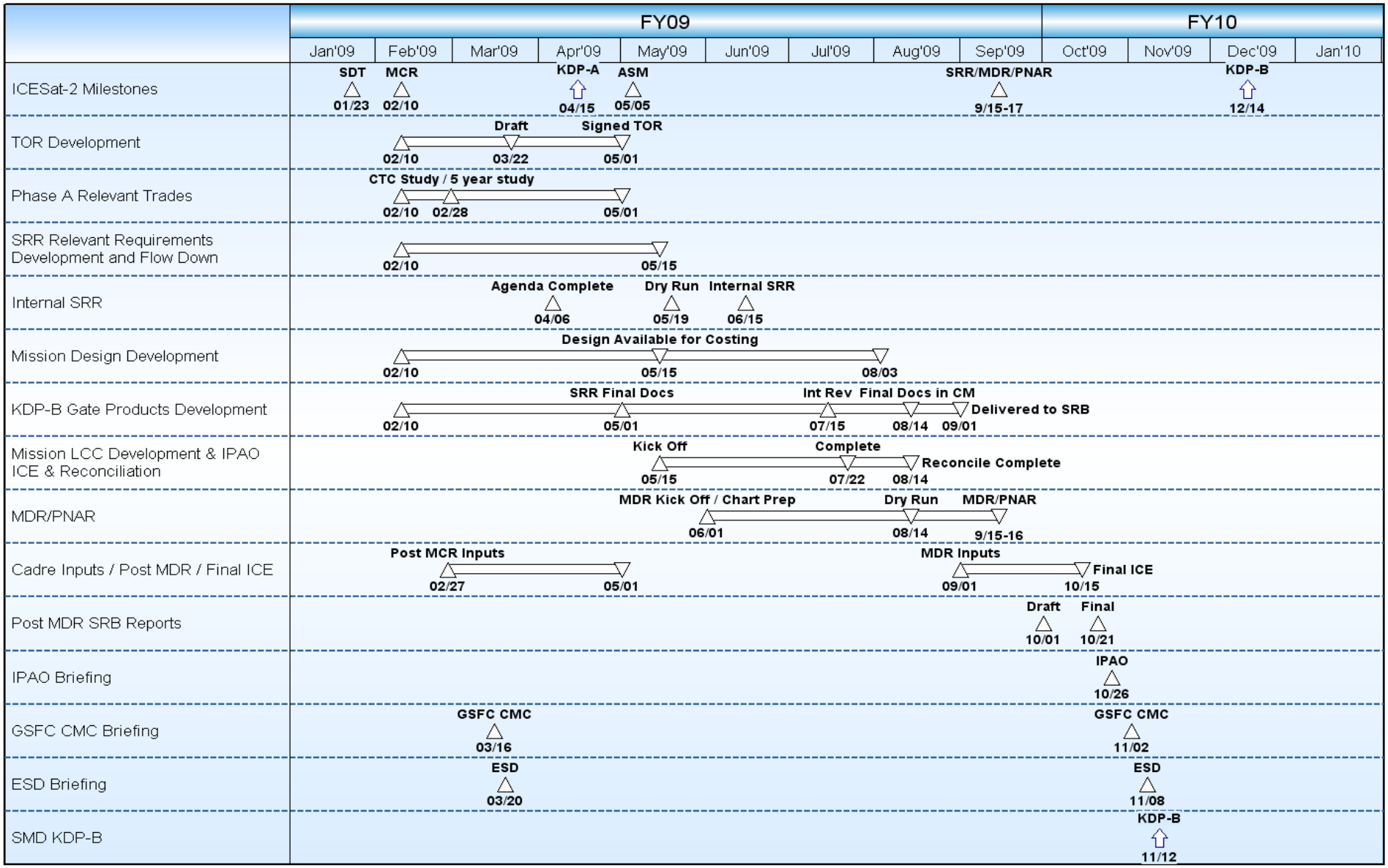


Laser Reference System

Lasers

ICESat-2 Phase A Plan - Summary

Goddard Space Flight Center



FY08 Activities
ICESat-2 aSDT

Goddard Space Flight Center

- **Objectives**
  - Develop science requirements for ICESat-2 consistent with guidance in the Decadal Survey
  - Identify key mission and instrument parameters that determine the ability to meet those science requirements
  - Perform sensitivity analyses of those key parameters in order to understand the trade space

- **Parameters examined (mission-discriminating)**
  - Need for cross-track (multiple beam) measurements
  - Footprint size and spacing of primary beam and resulting impacts on noise
  - Laser energy of primary beam required for sufficient ice sampling
  - Field of view ability to mitigate forward scattering effects

FY08 Activities
ICESat-2 aSDT Key Findings

Goddard Space Flight Center

- **Measurement errors increase as footprint size of primary laser beam decreases and along-track spacing increases.**
  - 140 m along-track footprint spacing (50Hz) is adequate for ice sheets
  - 50 to 70 m footprint size is required to reduce measurement noise from ice surface roughness
  - Vegetation science community desires smaller footprint size and higher sampling rate (e.g. 25 m, 240 Hz, and five laser beams
- **A single primary beam is adequate for science objective of 5-year average ice sheet trends**
- **Cross-track (multiple-beam) measurements are required to meet science requirements of annually and seasonally resolved elevation and mass changes, particularly in areas with larger surface slopes or with slopes changing with time**

FY08 Activities
ICESat-2 aSDT Key Findings (Cont'd)

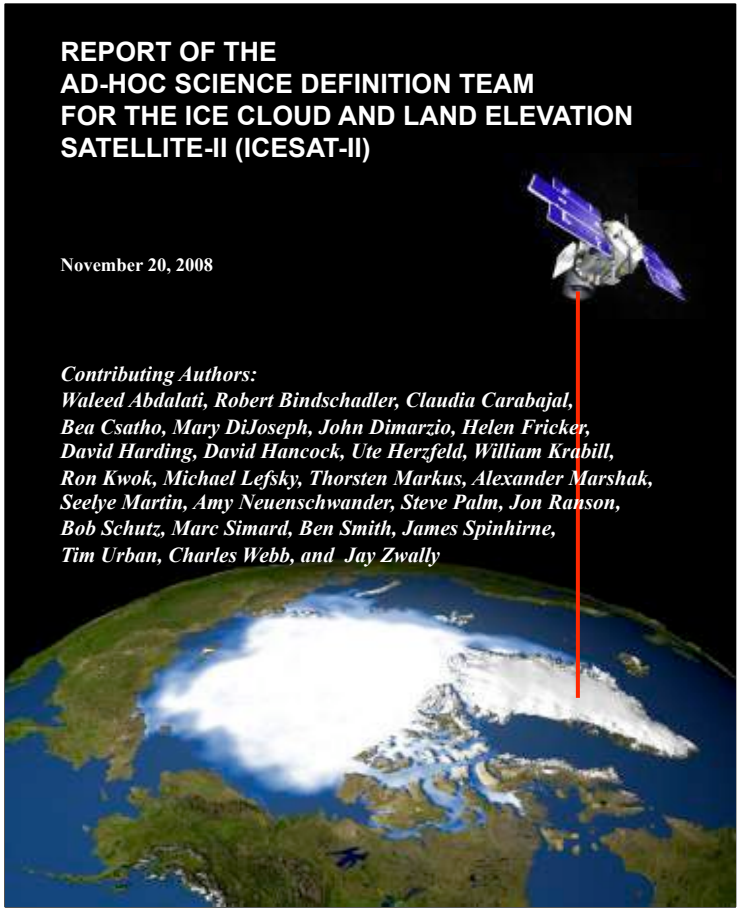
Goddard Space Flight Center

- **ICESat-1 data show return rates decrease by 4% per mJ of transmit energy**
  - 50 mJ minimum laser energy required with a 1-m telescope
- **It is possible to sufficiently minimize forward scattering effects with instrument FOVs of 160 microrads (100 m).**
  - Can accommodate 50-70 m footprints.

Draft Level 1 Science Requirements Based on aSDT Studies

Goddard Space Flight Center

- aSDT report submitted on Nov. 21
  - **http://cires.colorado.edu/~waleed**
- Level-1 science requirements defined consistent with Decadal Survey science objectives.
- Team Leader and 13 of 14 members of new SDT participated in aSDT.
- January 2009: SDT reviewed and concurred on essential results and conclusions of the aSDT, including science requirements for a 5-year mission and the need for the cross-track channel.



FY08 Activities
Mission Study Summary

Goddard Space Flight Center

- **Orbit study**
  - Confirmed 94 degree, 91-day repeat, precision orbit determination at 600km, and repeats ICESat-1 ground track
- **Launch Vehicle Options**
  - EELV is our baseline, very large lift mass and fairing volume
  - Taurus II – good margins on lift mass and fairing volume, but not on NLS list
- **Pointing Requirements Study**
  - Need to point to repeat ground track and know where spot is located on ground
    - 3-axis stabilized, nadir-pointing
    - Point spot to 30m
    - Geo-locate spot to 4.5m

    } Confirms need for LRS
  - Need to off-point up to 5 degrees

FY08 Activities
Mission Study Summary (Cont'd)

Goddard Space Flight Center

- **In-House Spacecraft Studies**
  - Completed MDL design for 3yr & 5yr single beam missions
  - Baseline is out-of-house spacecraft procurement
- **Out-of-House Spacecraft**
  - Generated plan for spacecraft procurement documentation
  - Documents to be ready 4/09 and solicitation by 7/09

FY08 Activities
Instrument Summary

Goddard Space Flight Center

- **Instrument Performance Model**
  - Given range error requirement, study was completed showing trade space for primary telescope diameter, detector sensitivity and laser energy. Iterated with aSDT
  - Model results on VSDE. Found by following this pathway:
    - ICESat-2 / 5.0 - Instrument / Instrument Systems Engineering
- **Telescope Study**
  - Considering Beryllium, SiC, and Composite material assemblies
  - Beryllium appears to be the most promising at this point,
  - The GLAS telescope (beryllium) was removed from storage and inspected. It was found to be in good condition and preparations are underway to complete fabrication of this unit.

FY08 Activities
Instrument Summary (Cont'd)

Goddard Space Flight Center

- **Detector Study**
  - Detector procurement plan includes completing multiple vendor study contracts and evaluate breadboard detectors. The results of these studies will be used to select and fund flight detectors
  - Vendors include ICESat-1 vendor and others
  - Detector study contracts in place, and results will be completed in February 2009
  - Procurement personnel assigned for flight detector procurement

- **Digitizer Study**
  - Examined digitzer options, performance drivers, risk assessment, and technology readiness
  - EEE Parts survey indicates parts used in ICESat I do not exist today for implementing an identical design
  - Lab tests on breadboard hardware and simulations underway now
  - Study papers located on VSDE. Found by following this pathway:
    - ICESat-2 / 5.0 - Instrument / Electrical Systems (IEM and Detector Electronics) / Studies Plans

FY08 Activities
Instrument Summary (Cont'd)

Goddard Space Flight Center

- **Transmitter Study**
  - Model philosophy developed to bring system from GLAS to ATLAS
    - Incorporates lessons learned from past laser altimeter developments as appropriate
    - GLAS ETU laser surpassed 1.2 billion shots
  - Summary paper completed outlining the changes from GLAS to ATLAS
  - Transmitter Model Philosophy located on VSDE. Found by following this pathway:
    - ICESat-2 / 5.0 - Instrument / Laser Integrated Product Team / Requirements and Systems Engineering
- **Study for cross-track channel has been bounded and plans in place to begin study after MCR**
- **Developing packaged breadboards for LRS and Laser**

FY08 Activities
Project Level

Goddard Space Flight Center

- **Completed Mission Concept Review (MCR)**

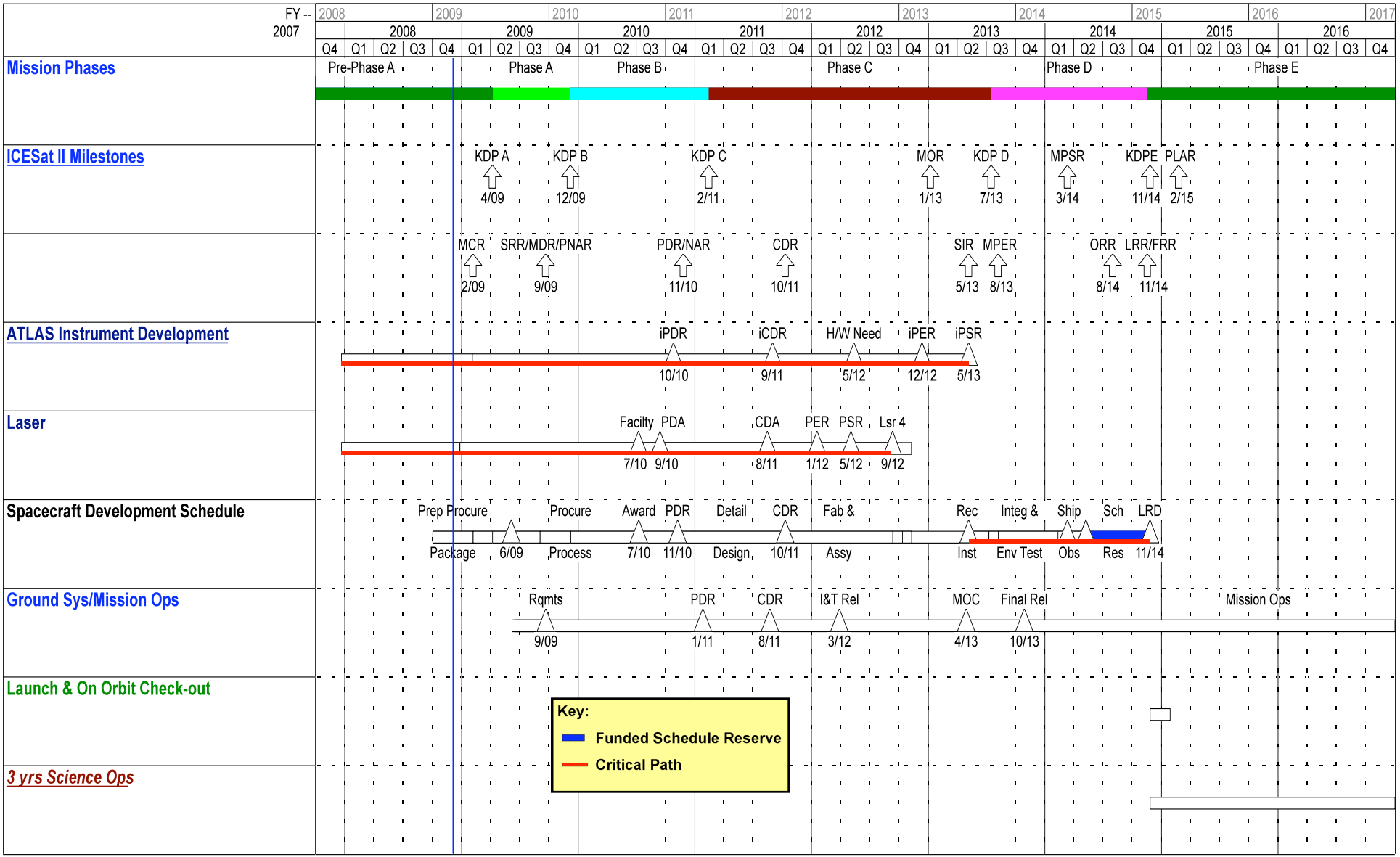
- **The following Documents were completed:**

  - Draft program requirements (Level 1's)
  - Preliminary Review Plan
  - Draft Mission Requirements Document
  - Draft Concept of Operations
  - Developed an integrated schedule with 2000+ line items
  - Developed WBS to level 4+
  - Top level mission schedule
  - FAD
  - Integrated Baseline
  - Work Agreements
  - Draft TOR
  - Submit Waivers for MCR/KDP-A (none identified to date)
  - Draft New Technology Development Plan

ICESat-2 Mission Master Schedule

Baseline Version -- LRD = November 2014

Goddard Space Flight Center



ICESat-2 Phase A Plan - Summary

Goddard Space Flight Center

	FY09									FY10			
	Jan'09	Feb'09	Mar'09	Apr'09	May'09	Jun'09	Jul'09	Aug'09	Sep'09	Oct'09	Nov'09	Dec'09	Jan'10
ICESat-2 Milestones		SDT 01/23	MCR 02/10	KDP-A 04/15	ASM 05/05				SRR/MDR/PNAR 9/15-17			KDP-B 12/14	
TOR Development		02/10		Draft 03/22	Signed TOR 05/01								
Phase A Relevant Trades		CTC Study / 5 year study 02/10	02/28		05/01								
SRR Relevant Requirements Development and Flow Down		02/10			05/15								
Internal SRR				Agenda Complete 04/06	Dry Run 05/19	Internal SRR 06/15							
Mission Design Development		02/10			Design Available for Costing 05/15			08/03					
KDP-B Gate Products Development		02/10			SRR Final Docs 05/01		Int Rev 07/15	Final Docs in CM 08/14	Delivered to SRB 09/01				
Mission LCC Development & IPAO ICE & Reconciliation					Kick Off 05/15		Complete 07/22	Reconcile Complete 08/14					
MDR/PNAR					MDR Kick Off / Chart Prep 06/01			Dry Run 08/14	MDR/PNAR 9/15-16				
Cadre Inputs / Post MDR / Final ICE		Post MCR Inputs 02/27			05/01				MDR Inputs 09/01	Final ICE 10/15			
Post MDR SRB Reports									Draft 10/01	Final 10/21			
IPAO Briefing										IPAO 10/26			
GSFC CMC Briefing			GSFC CMC 03/16							GSFC CMC 11/02			
ESD Briefing			ESD 03/20							ESD 11/08			
SMD KDP-B										KDP-B 11/12			

ICESat-2 Mission Overview

Goddard Space Flight Center

Mission Science

1. Determine polar ice sheet mass balance; understand controlling mechanisms; examine how ice sheets will impact global sea level and ocean circulation in a changing climate.
2. Measure sea-ice thickness to understand ice/ocean/ atmosphere exchanges of energy, mass and moisture.
3. Vegetation cover and global biomass.

Primary FY09 Objectives & Deliverables

1. Complete the following reviews: MCR, KDP-A, SRR, MDR, PNAR
2. Develop mission concept, requirements, and design
3. Develop all spacecraft procurement documents for solicitation
4. Initiate instrument long lead procurements as necessary
5. Complete LRS and Laser prototype developments

Mission Implementation Challenges

1. Draft Level-1 Requirements Document
   - Ad-hoc SDT defined five year mission with cross track channel in response to Decadal Survey requirements.
   - At MCR, we showed Phase A study plans to derive the concept for these requirements.
   - As we prepare for SRR/MDR, need to decide whether to incorporate 5 year mission and cross track requirements
- Launch vehicle availability

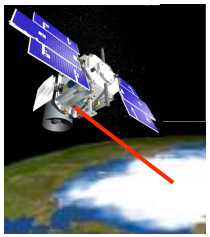
Mission Architecture

1. Repeat ICESat-1 ground-track and pointing
2. Instrument is an Ice Altimeter (Lidar)
   - One laser on at a time, 50 Hz rep rate, 50 mJ, 50-70m beam footprint with 140m spacing.
   - Surface range precision of 1-2cm
   - Ice footprint location knowledge to 4.5m on ground using Laser Reference System (LRS)
   - 1.0 - 1.5m telescope (reduces laser energy required)

Chart 7: Study Issues & Challenges

Goddard Space Flight Center

- **This is the "open mike" section of the presentation. Bring to the fore issues you think we need to hear, or challenges that as a group or within the ESD we may be able to assist.**
  - What are the drivers to reaching KDP-A?
  - What are you focusing your energy on?
  - What cross mission activities are you concerned about but can't afford to deal with?
  - What issues are too big for your group?
  - Are there technology readiness issues that are driving mission readiness (even at this early phase)?
  - What is the preferred approach for Science Development teams?
    - DESDynI and CLARREO? For Tier 2?
  - …



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Backup

Decision Schedule Flowchart

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